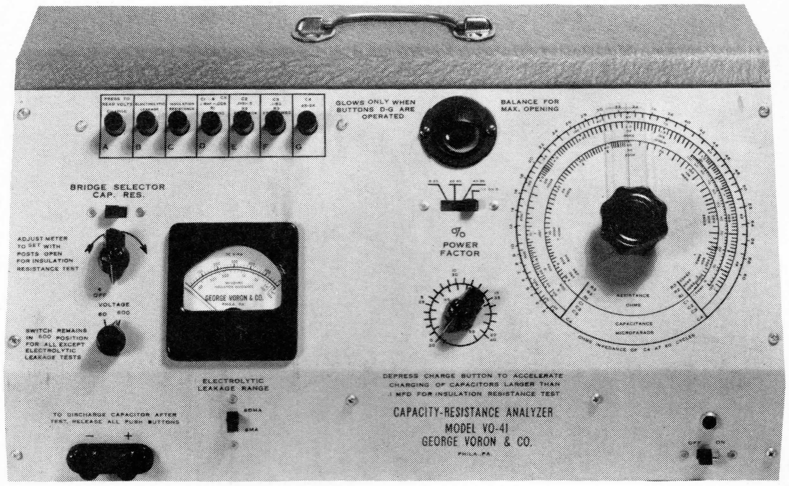
INSTRUCTION MANUAL

CAPACITY - RESISTANCE ANALYZER MODEL VO-41


GLOWS ONLY WHEN BUTTONS D-G ARE OPERATED
BALANCE FOR MAX. OPENING
BRIDGE SELECTOR
CAP. RES.
ADJUST METER TO SET WITH POSTS OPEN FOR INSULATION RESISTANCE TEST
VOLTAGE
SWITCH REMAINS IN 600 POSITION FOR ALL EXCEPT ELECTROLYTIC LEAKAGE TESTS
GEORGE VORON & CO.
POWER FACTOR
RESISTANCE
OHMS
CAPACITANCE
MICROFARADS
ELECTROLYTIC LEAKAGE RANGE
DEPRESS CHARGE BUTTON TO ACCELERATE CHARGING OF CAPACITORS LARGER THAN 1 MFD FOR INSULATION RESISTANCE TEST
TO DISCHARGE CAPACITOR AFTER TEST, RELEASE ALL PUSH BUTTONS
CAPACITY-RESISTANCE ANALYZER
MODEL VO-41
GEORGE VORON & CO.
PHILA. PA.
OFF ON
A
B
C
D
E
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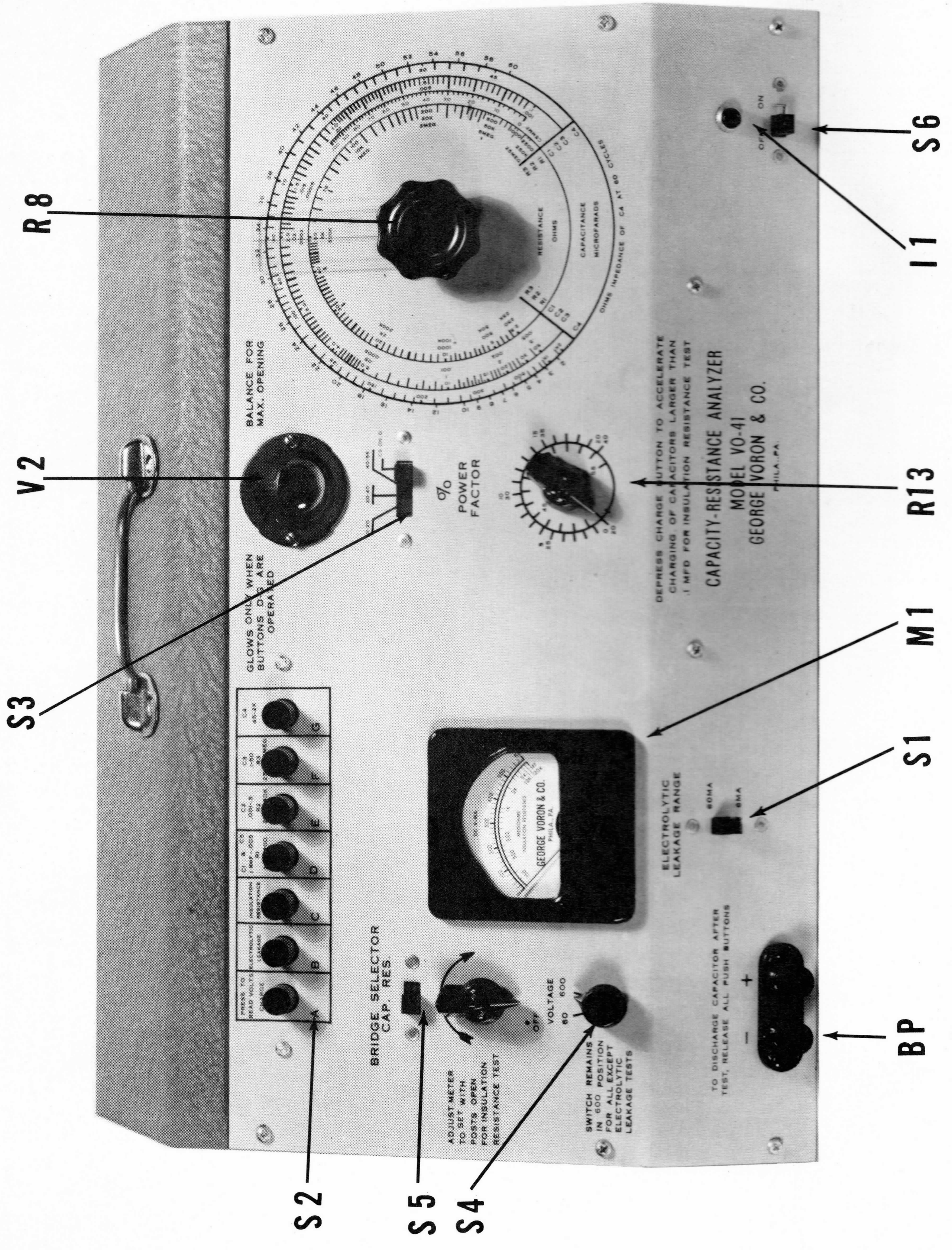
G

GEORGE VORON & COMPANY
PHILADELPHIA, PA.


S2
S5
S4
S3
V2
R8
I1
S6
R13
M1
S1
BP
CAPACITY-RESISTANCE ANALYZER
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TO DISCHARGE CAPACITOR AFTER TEST, RELEASE ALL PUSH BUTTONS
RESISTANCE OHMS
CAPACITANCE MICROFARADS
OHMS IMPEDANCE OF C4 AT 60 CYCLES
A
B
C
D
E
F
G

FIGURE 1. FRONT VIEW VO-41

OPERATING INSTRUCTIONS CAPACITY-RESISTANCE ANALYZER VO-41

1. GENERAL

1.1 The Capacity-Resistance Analyzer Model VO-41 is a composite measuring and testing instrument. It is an accurate multi-range resistance and capacitance bridge and measures the insulation resistance or the leakage current and the 60 cycle power factor of the various types of capacitors.

Push-button range and function selection, large calibrated dials, panel meter and magic-eye bridge balance indicator mounted on a sloping panel make the instrument easy to use and to read.

Hazardous voltages are removed from binding posts and capacitors connected to binding posts are discharged when all push-buttons are released.

1.2 Technical Characteristics

Tube Complement: 1—1619, 1—12J5, 1—1629
Voltage: 110-120V AC
Frequency: 60 cycle
Power Consumption: 35 watts
Accuracy: Within 5% through top 180° of scale, within 10% at scale extremes.

1.3 Physical Characteristics

Dimensions: 18″ l. x 9″ h. x 8″ deep
Weight: 14 lbs.

1.4 Equipment Features

The types of tests which can be performed and the range limits are described in the following subparagraphs.

1.4.1 RESISTANCE—Three ranges provide for measurement of resistors from 2.5 ohms to 25 megohms.

R1 Range	2.5 ohms to 2500 ohms
R2 Range	250 ohms to 250K ohms
R3 Range	25K ohms to 25 megohms

1.4.2 CAPACITANCE—Five capacitance ranges permit fast and accurate measurements from 1 mmf. to 2000 mf.

C1 Range	.0001	to .005 mf.
C2 Range	.001	to .5 mf.
C3 Range	.1	to 50 mf.
C4 Range	45.	to 2000 mf.
C5 Range	1	to 100 mmf.

1.4.3 INSULATION RESISTANCE—Insulation resistance measurements from 100 to 20,000 megohms may be made with the VO-41. The VO-41 determines the insulation resistance of the capacitor by measuring the amount of current which passes through it. The insulation resistance is read on the panel meter which is calibrated in megohms.

1.4.4 POWER FACTOR—The power factor test is one of two features built in for use in determining the worth of electrolytic capacitors. The power factor of the electrolytic capacitor under test is indicated directly on a three range percentage scale.

1.4.5 LEAKAGE CURRENT—The leakage test is a second feature used to determine the condition of electrolytic capacitors. An integral dc supply with a continuously variable range of 0-600v provides for leakage current measurements at the rated voltage of the capacitor under test. The leakage current is read on the panel meter.

2. RESISTANCE MEASUREMENTS

2.1 A simplified circuit for the three range ac wheatstone bridge is shown in Figure 2. The resistance standard for the R1 range is 50 ohms, for the R2 range—5000 ohms, and for the R3 range—500,000 ohms. The standards are fixed-film type and are accurate within 1%.

2.2 Test Procedure

(a) Turn on power and allow 30 seconds for equipment to warm up.
(b) Turn Voltage Switch to 600 position.
(c) Connect resistor to be measured across the binding posts.
(d) With Bridge Selector Switch in RES. position, select the proper scale by depressing the appropriate push-button.

SCALE	PUSH-BUTTON	RESISTANCE
R1	D	2.5 ohms to 2500 ohms
R2	E	250 ohms to 250K ohms
R3	F	250,000 ohms to 25 megohms

(e) Adjust the Bridge Dial for maximum opening on the magic-eye tube. Read the resistance of the part under test directly from the scale.
(f) Release push-button and remove resistor from binding posts.

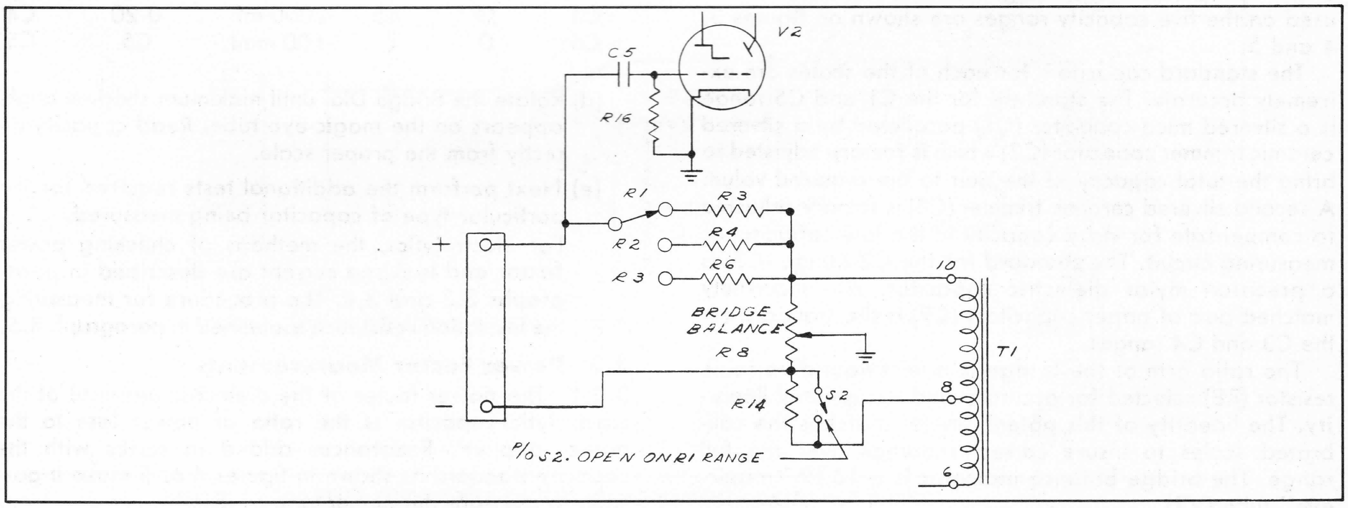

FIGURE 2. RESISTANCE BRIDGE CIRCUIT

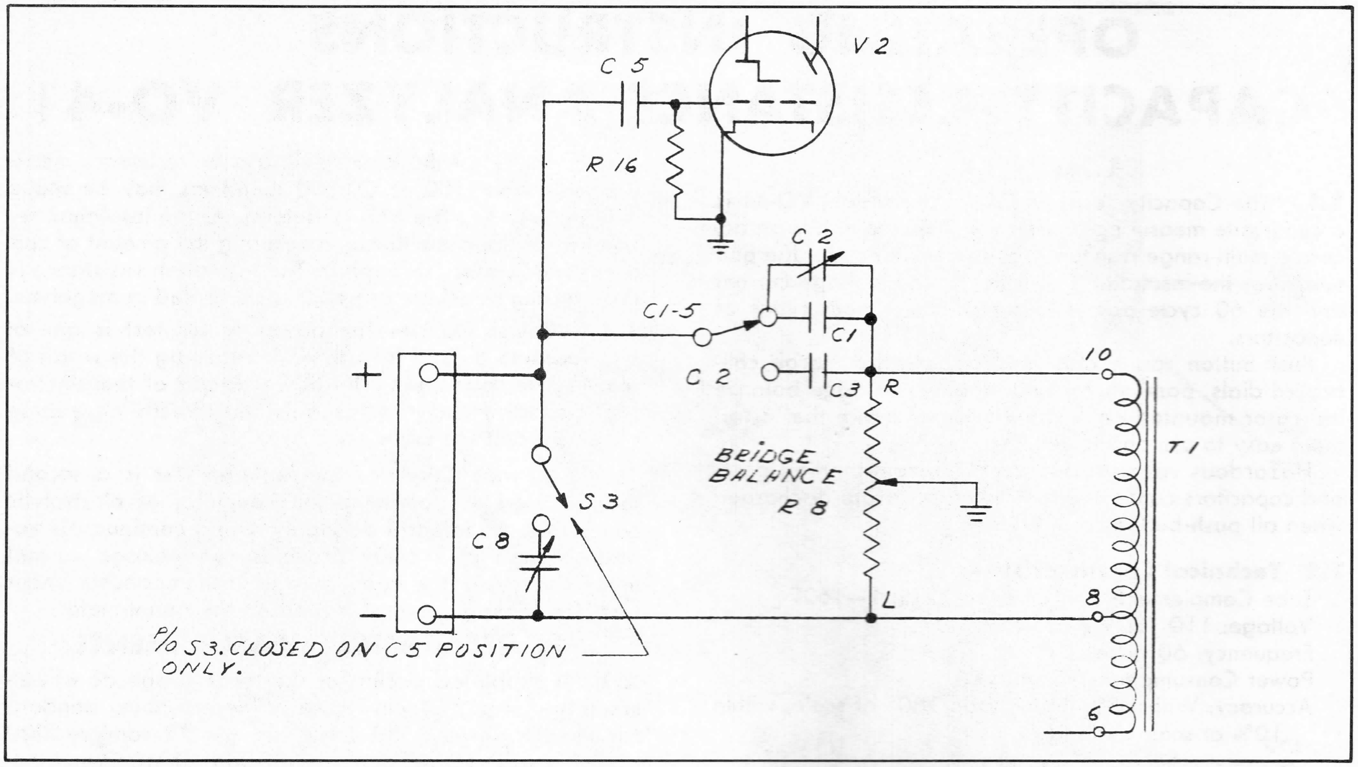

FIGURE 3. LOW CAPACITY BRIDGE CIRCUIT C1, C2, C5 RANGES

3. TESTING OF CAPACITORS

3.1 Capacitors fall into two general categories—electrostatic and electrolytic. Paper, mica, and ceramic capacitors are electrostatic types. Larger capacitors are usually the dry electrolytic type.

The capacity of both types is measured in the same way. Each type requires further testing in order to ascertain its worth as a circuit component.

The insulation resistance of electrostatic types is extremely important. A capacitor with low insulation resistance is generally referred to as being "leaky."

The power factor and the leakage current of electrolytic capacitors are equally important. Capacitors should be discarded if they fall outside the prescribed limits on the tests listed below even though their capacity is correct.

3.2 Measuring Capacitors

3.2.1 Simplified circuit diagrams of the bridge circuits used on the five capacity ranges are shown on figures 3, 4 and 5.

The standard capacitors for each of the scales are extremely accurate. The standard for the C1 and C5 range is a silvered mica capacitor (C1) paralleled by a silvered ceramic trimmer capacitor (C2) which is factory adjusted to bring the total capacity of the pair to the required value. A second silvered ceramic trimmer (C8) is factory adjusted to compensate for stray capacity in the low capacitance measuring circuit. The standard for the C2 Range (C3) is a precision mylar dielectric capacitor. An accurately matched pair of paper capacitors (C9) is the standard for the C3 and C4 ranges.

The ratio arm of the bridge is a wirewound variable resistor (R8) selected for accuracy and exceptional linearity. The linearity of this potentiometer matches the calibrated scales to insure correct readings over the full range. The bridge balance indicator is a 1629 "magic-eye" tube (V2).

3.2.2 TEST PROCEDURE

(a) Turn on power and allow 30 seconds for equipment to warm up.

(b) With Bridge Selector in "CAP" position, Voltage Control to "OFF" position, and Voltage Switch in "600" position, connect the capacitor to be tested to the binding posts. Capacitors smaller than .001 mf. should be connected directly to the binding posts. Larger capacitors can be connected by means of test leads. ALWAYS CONNECT ELECTROLYTIC CAPACITORS IN THE PROPER POLARITY.

(c) Select the range to be used by depressing the appropriate push-button.

SCALE	PUSH-BUTTON	CAPACITANCE	P-F SWITCH	SCALE
C1	D	.0001-.005 mf.	0-20	C1
C2	E	.001 -.5 mf.	0-20	C2
C3	F	.5 -50 mf.	0-20	C3
C4	G	45 -2000 mf.	0-20	C4
C5	D	1 -100 mmf.	C5	C5

(d) Rotate the Bridge Dial until maximum shadow angle appears on the magic-eye tube. Read capacity directly from the proper scale.

(e) Next perform the additional tests required for the particular type of capacitor being measured.

For electrolytics, the methods of checking power factor and leakage current are described in paragraphs 3.3 and 3.4. The procedure for measuring the insulation resistance is outlined in paragraph 3.5.

3.3 Power Factor Measurements

3.3.1 The power factor of the dielectric material of the electrolytic capacitor is the ratio of power loss to the power applied. Resistances added in series with the capacity standard as shown in figures 4 or 5 make it possible to measure the percentage of loss.

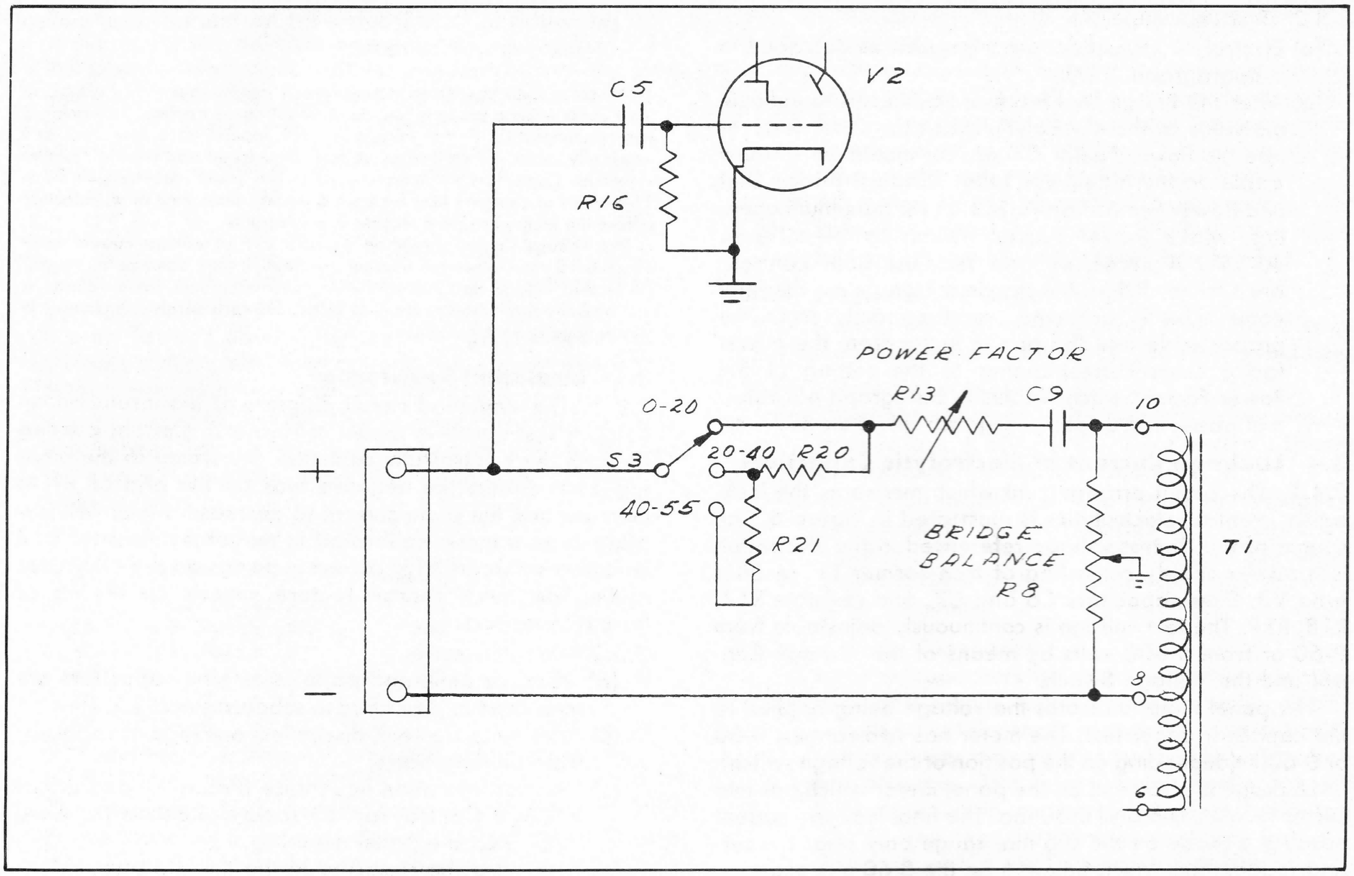

FIGURE 4. CAPACITY AND POWER FACTOR MEASUREMENT CIRCUIT—C3 RANGE

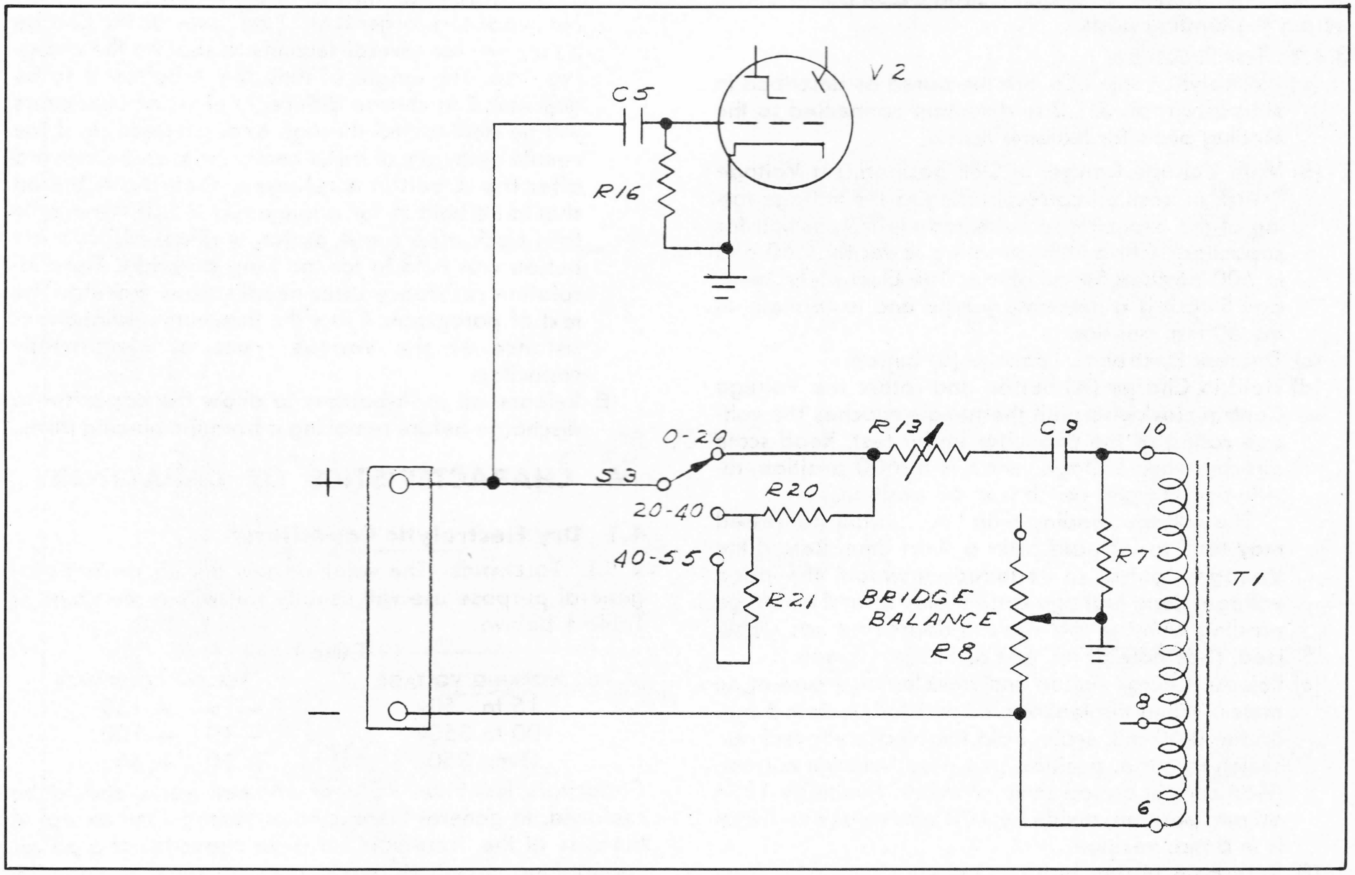

FIGURE 5. CAPACITY AND POWER FACTOR MEASUREMENT CIRCUIT—C4 RANGE

3.3.2 Test Procedure

(a) Electrolytic capacitors are measured as described in subparagraph 3.2.2.

(b) After the Bridge Dial has been balanced to indicate the value of the electrolytic capacitor under test, rotate the Power Factor Control for maximum shadow angle on the magic-eye tube. Readjust Bridge Dial and Power Factor Control in turn for maximum opening. Move Power Factor Switch to 20-40% or 40-55% if necessary and readjust both controls once more. When the maximum angle on the indicator tube is achieved, read capacity from the proper scale and the power factor from the power factor scale corresponding to the setting of the Power Factor Switch. Tables in paragraph 4 list normal power factor percentage for good electrolytics.

3.4 Leakage Current of Electrolytic Capacitors

3.4.1 The circuit arrangement which measures the leakage current of electrolytics is illustrated in Figure 6. The source of the dc test voltage referenced in the illustration is a power supply consisting of transformer T1, rectifier tube V3, filter capacitors C6 and C7, and resistors R17, R18, R19. The test voltage is continuously adjustable from 0-60 or from 0-600 volts by means of the Voltage Control and the Voltage Switch.

The panel meter indicates the voltage being applied to the capacitor under test. The meter has two ranges, 0-60 or 0-600 v(depending on the position of the voltage switch).

Leakage is also read on the panel meter which has two current scales, 0-6 and 0-60 ma. The final leakage current reading is made on the 0-6 ma. range only after the current reading has fallen below 6 on the 0-60 ma. scale.

Resistor R17 in series with the power supply voltage limits current to 60 ma. even if a short circuit is introduced across the binding posts.

3.4.2 Test Procedure

(a) Electrolytic capacitors are measured as described in subparagraph 3.2.2 and remain connected to the binding posts for leakage tests.

(b) With Voltage Control in OFF position, set Voltage Switch in position corresponding to the voltage rating of the capacitor to be tested—in 60 position for capacitors with a voltage rating lower than 60 and in 600 position for all others. The Electrolytic Leakage Switch is a momentary type and is normally in the 60 ma. position.

(c) Depress Electrolytic Leakage (B) button.

(d) Hold in Charge (A) button and rotate the Voltage Control clockwise until the needle reaches the voltage rating of the capacitor under test. Read scale directly when voltage switch is in 600 position, divide by 10 when switch is in 60 position.

The voltage reading with "A" button depressed may tend to increase after a short time. Retard the Voltage Control as required; maintain the rated voltage. Read leakage current only after the voltage reading with the "A" button depressed has stabilized. (See note at the end of this paragraph.)

(e) Release Charge button and read leakage current on meter. When the leakage current falls below 6 ma. on the 0-60 ma. scale, hold the electrolytic leakage switch in 6 ma. position and read leakage current. Read current on top scale of meter. Divide by 10 in 60 ma. position; divide by 100 when leakage switch is in 6 ma. position.

(f) Release B button before removing capacitor from binding posts. This action discharges the capacitor and eliminates the hazard of shock.

(g) Tables in paragraph 4 list normal leakage current for good electrolytics.

Note: Electrolytic capacitors deteriorate in storage but will "re-form" in most cases when a properly polarized dc voltage is applied. Re-forming is best accomplished if the voltage is first applied at a low level and gradually increased until rated voltage is reached and leakage current stabilizes. Capacitors which have been on the "shelf" may require 10 or 15 minutes of charging time for each 6 months since date of manufacture before the leakage current reaches a stable value.

The Voltage Control should be retarded so that leakage current never exceeds 10 ma.—otherwise internal overheating may damage the capacitor. Raise voltage as leakage current decreases until rated voltage is reached. An intermittent capacitor will cause considerable fluctuation in the leakage current indication.

3.5 Insulation Resistance

3.5.1 The simplified circuit diagram of the insulation resistance test circuit is shown in Figure 7. Current passing through the electrostatic capacitor connected to the binding posts causes the negative bias on the grid of V1 to increase and the plate current to decrease. Meter M1 is a plate current meter calibrated in megohms. Resistor R12 is factory calibrated for correct readings on the resistance scale. The quick charge feature speeds up testing of larger capacitors.

3.5.2 Test Procedure

(a) Mica, ceramic and paper dielectric capacitors are measured as described in subparagraph 3.2.2.

(b) After measurement, disconnect one lead of capacitor from binding posts.

(c) Depress Insulation Resistance button (C) and adjust Voltage Control for full scale deflection (to word "SET") on the panel meter.

(d) Reconnect the capacitor to the binding post.

(e) The insulation resistance of smaller capacitors—less than .1 mf.—may now be read on the panel meter. For capacitors larger than .1 mf. depress the Charge button (A) for several seconds to shorten the charging time. The length of time the A button is to be depressed to charge different values of capacitors will be determined through experimentation. If the needle of the panel meter continues to creep forward after the A button is released, then the A button should be held in for a longer period. If the needle falls back after the A button is released, then the button was held in for too long a period. Read insulation resistance after needle stops moving. The text of paragraph 4 lists the minimum insulation resistance of the various types of electrostatic capacitors.

(f) Release all push-buttons to allow the capacitor to discharge before removing it from the binding posts.

4. CHARACTERISTICS OF CAPACITORS

4.1 Dry Electrolytic Capacitors

4.1.1 Tolerance—The value of new dry electrolytics for general purpose use will usually fall within the limits of Table 1 below:

Table 1

DC WORKING VOLTAGE	PERCENT TOLERANCE	
15 to 50v	− 10	+ 150
100 to 350v	− 10	+ 100
Over 350v	− 10	+ 50

Capacitors less than 75% of nominal value should be replaced. In general there is no maximum limit except in the case of the "reservoir" or input capacitor of a power supply filter circuit. Here any great increase in capacity will raise the output voltage level and may increase rectifier current beyond permissible limits.

4.1.2 Power Factor—Most new dry electrolytics for general purpose use will have a power factor of less than 10%. All new dry electrolytics will have power factors less than the maximum values listed in Table 2 below:

Table 2—60 Cycle Power Factor

DC WORKING VOLTAGE	MAX P. F.	DC WORKING VOLTAGE	MAX P. F.
15	50	150	20
25	30	250	18
50	25	Over 300	15

Capacitors with voltage ratings of 150v or more should be replaced if the 60 cycle power factor is twice the figure on Table 2 above. The low voltage sections of new multiple-section electrolytics may have a power factor 50% higher than values shown above.

4.1.3 Leakage Current—The leakage current of new dry electrolytics for general purpose use should not exceed the value computed from the applicable formula in Table 3 below:

Table 3

DC WORKING VOLTAGE	LEAKAGE FORMULA*	DC WORKING VOLTAGE	LEAKAGE FORMULA*
15	I = 0.001C + 0.1	250	I = 0.013C + 0.8
25	I = .002C + .1	300	I = .016C + .8
50	I = .004C + .1	350	I = .019C + .85
100	I = .007C + .15	400	I = .023C + .87
150	I = .010C + .2	450	I = .033C + .9
200	I = .011C + .8	Above 450	I = .04C + .94

* I represents the dc leakage in milliamperes and C represents the nominal capacitance in microfarads.

The amount of leakage will increase with age and high temperature. As a general rule, any electrolytic with more than 15 ma. of leakage current should be discarded.

4.1.4 Miscellaneous Information on Electrolytic Capacitors

(a) Certain large capacitors used in television receivers are rated in terms of their 60 cycle impedance. Such capacitors are measured in the same manner as other electrolytics but the 60 cycle impedance is read on the outer scale of the C4 range.

(b) AC motor starting electrolytics which measure 15% below their nominal capacity or which have a power factor higher than 15% should be replaced.

4.2 Electrostatic Capacitors

Most electrostatic capacitors will fall within the tolerances for value and insulation resistance given in the text below.

4.2.1 Mica Capacitors

(a) Tolerance—Mica capacitors which are not otherwise marked are ±20% units. Color coded capacitors should have tolerances as marked.

(b) Insulation Resistance—The insulation resistance of new molded mica capacitors will exceed 3000 megohms. The insulation resistance of new silvered mica and other higher quality capacitors will exceed 6000 megohms.

4.2.2 Ceramic Capacitors

(a) Ceramic capacitors which are not otherwise marked are ±20% units. Color coded ceramic capacitors should have tolerances as marked. The capacity of ceramic types may vary considerably with temperature changes. The capacity will usually fall within tolerances when measured at room temperature (25°C). The capacity measurement may increase or decrease with a rise in temperature depending on

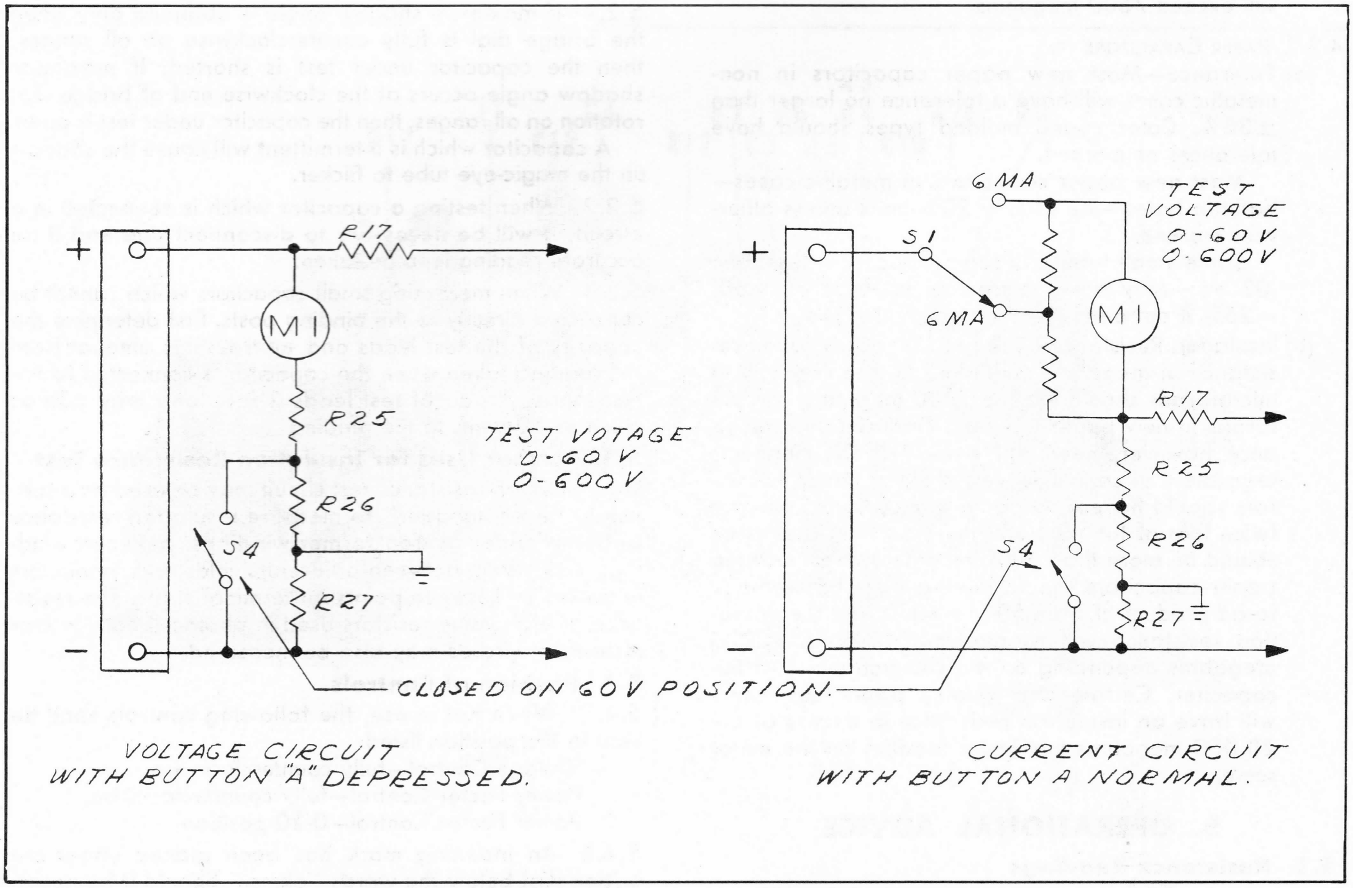

FIGURE 6A. LEAKAGE CURRENT MEASURING CIRCUIT FIGURE 6B

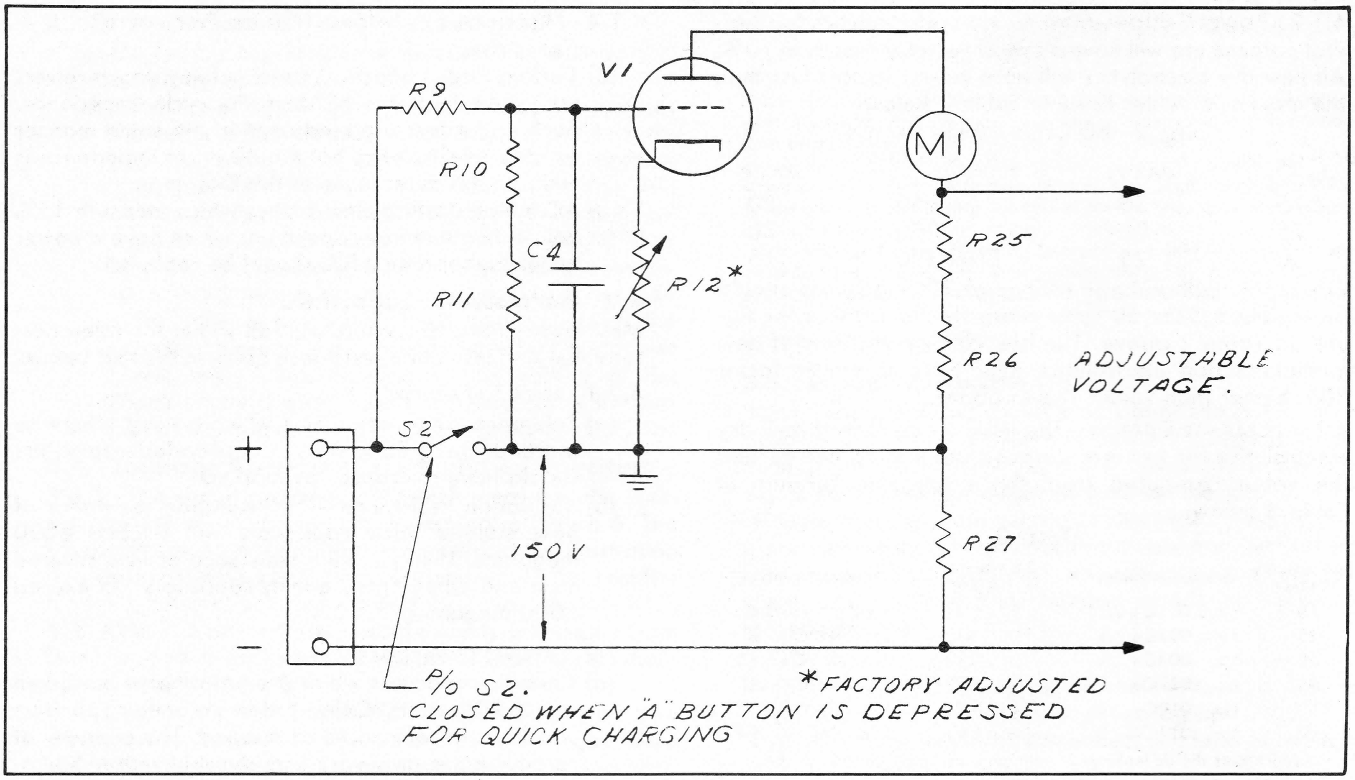

FIGURE 7. INSULATION RESISTANCE MEASURING CIRCUIT

whether the dielectric material has a positive or a negative temperature coefficient.

(b) The insulation resistance of new ceramic capacitors will exceed 7500 megohms.

4.2.3 PAPER CAPACITORS

(a) Tolerance—Most new paper capacitors in non-metallic cases will have a tolerance no larger than ±30%. Color coded molded types should have tolerances as marked.

Most new paper capacitors in metallic cases—bathtub types—are usually 20% units unless otherwise marked.

Some small tubular paper capacitors—less than .02 mf.—may have tolerances as wide as +60, −25% if not otherwise marked.

(b) Insulation Resistance—The product of insulation resistance in megohms multiplied by the capacity in microfarads should exceed 1000 megohms—microfarads in new paper tubulars. The insulation resistance however, need not exceed 5000 megohms regardless of capacity. New molded paper capacitors should have a megohm x microfarad product twice that of tubulars and the insulation resistance should be more than 6000 megohms. New bathtub paper capacitors should have a megohm x microfarad product of from 500 to 4000 and the insulation resistance will range from 1500 to 12000 megohms depending on the characteristics of the capacitor. Certain high quality paper capacitors will have an insulation resistance in excess of the 20,000 megohms maximum reading on the meter scale.

5. OPERATIONAL ADVICE

5.1 Resistance Readings

The measurements taken with the ac wheatstone bridge and those taken with an ohmmeter will not necessarily agree, especially when inductively wound resistors are being measured.

5.2 Capacity Measurements

5.2.1 If maximum shadow angle is obtained only when the bridge dial is fully counterclockwise on all ranges, then the capacitor under test is shorted. If maximum shadow angle occurs at the clockwise end of bridge dial rotation on all ranges, then the capacitor under test is open.

A capacitor which is intermittent will cause the shadow on the magic-eye tube to flicker.

5.2.2 When testing a capacitor which is connected in a circuit, it will be necessary to disconnect one end if an accurate reading is to be taken.

5.2.3 When measuring small capacitors which cannot be connected directly to the binding posts, first determine the capacity of the test leads and subtract this amount from the reading taken when the capacitor is connected to the test leads. A pair of test leads 2 feet long may add as much as 10 mmf. to the reading.

5.3 Further Uses for Insulation Resistance Test

The insulation resistance test circuit may be used as a substitute for a "megger" to measure insulation resistance between motor or transformer windings, between windings and frame, between adjacent shields and conductors in cables or between points on terminal strips. The resistance of high value resistors used in photocell and nuclear instrument circuits may also be measured.

5.4 Position of Controls

5.4.1 When not in use, the following controls shall be kept in the position listed:

Voltage Control—fully counterclockwise.
Power Factor Control—fully counterclockwise.
Power Factor Control—0-20 position.

5.4.2 An indexing mark has been placed under the bridge dial below the words "ohms." Should it be necessary to remove the knob, this indexing mark can be used to re-position the pointer.

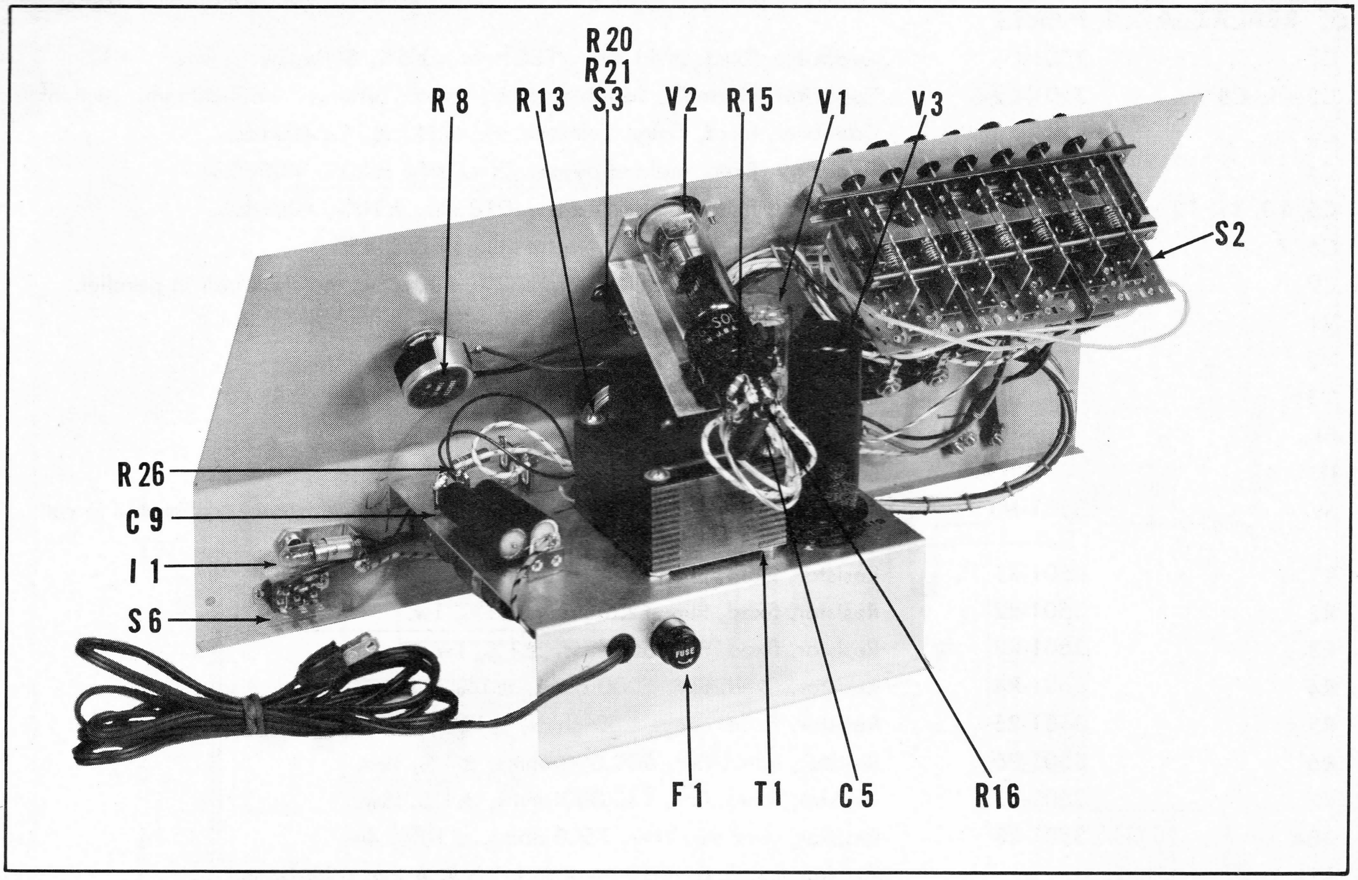

FIGURE 8. REAR VIEW VO-41

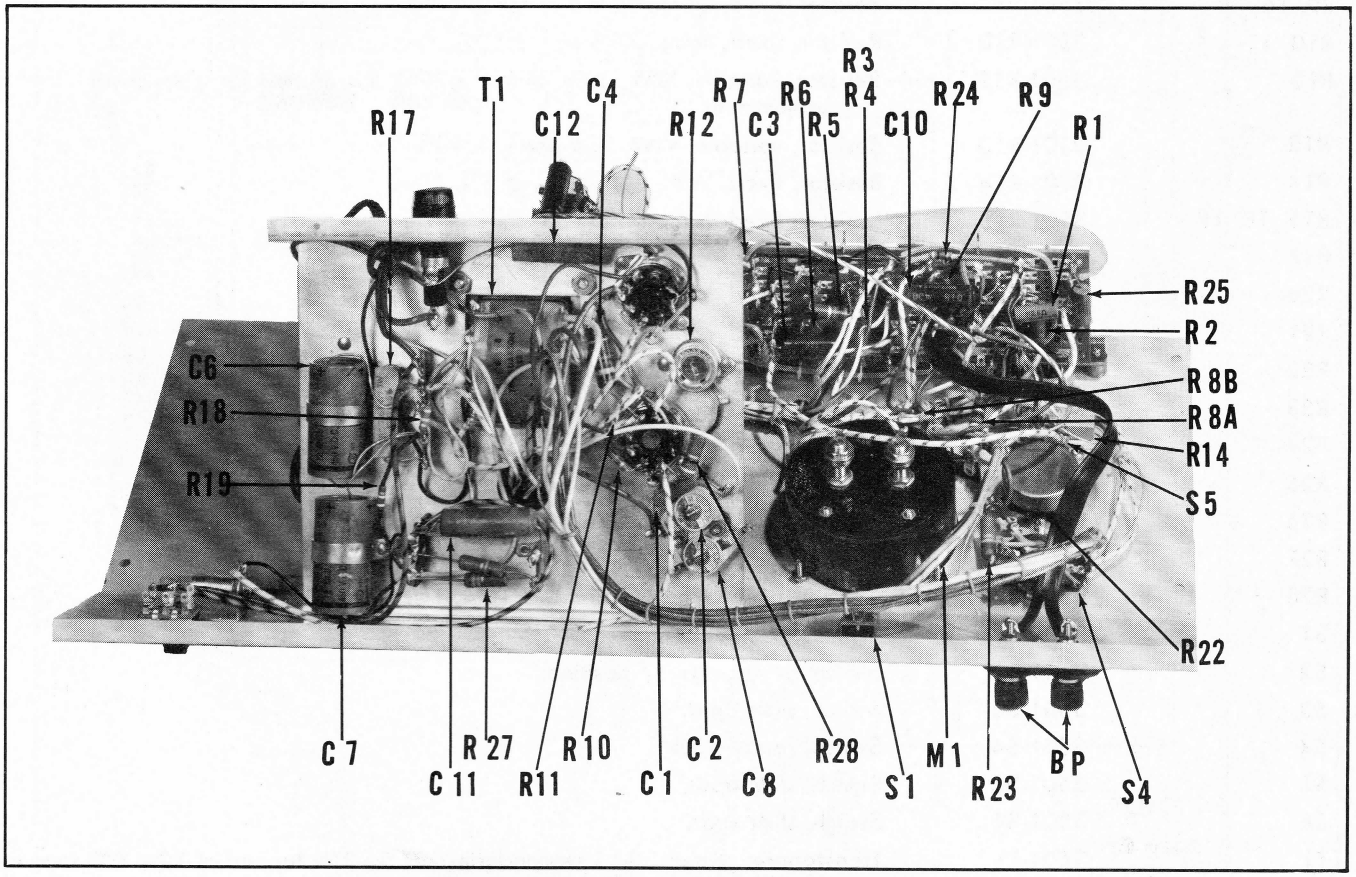

FIGURE 9. BOTTOM VIEW VO-41

6. REPLACEABLE PARTS

C1	3501-C1	Capacitor, fixed, silver mica; 180 mmf., ±5%, 500vdcw.
C2 and C8	3501-C2-8	Capacitor Assembly, variable trimmer, silver ceramic; two 4-30 mmf. sections.
C3	3501-C3	Capacitor, fixed, mylar dielectric, .02 mmf., ±2%, 400vdc.
C4	3501-C4	Capacitor, fixed, molded paper; .0047 mf., ±20%, 400vdcw.
C5, 10, 11, 12	3501-C5	Capacitor, fixed, molded paper; .018 mf., ±10%, 400vdcw.
C6, 7	3501-C6	Capacitor, fixed, tubular, electrolytic, 12 mf., 450v.
C9	3501-C9	Capacitor, fixed, paper, 2 mf., ±2%, 400vdcw, matched pair in parallel.
V1		Electron Tube, 12J5GT.
V2		Electron Ray Tube, 1629.
V3		Electron Tube, 1619.
F1		Fuse Cartridge 3AG, 1A.
I1		Lamp, indicator #47.
M1	3501-M1	Milliammeter, D.C., 0-5 range, 25 ohms internal resistance; calibrated in volts, milliamperes and megohms.
R1	3501-R1	Resistor, fixed, film, 112.5 ohms, ±1%, 1w.
R2	3501-R2	Resistor, fixed, film, 12.5 ohms, ±1%, 1w.
R3	3501-R3	Resistor, fixed, film, 50 ohms, ±1%, 1w.
R4	3501-R4	Resistor, fixed, film, 5000 ohms, ±1%, 1 w.
R5	3501-R5	Resistor, fixed, comp, 100 ohms, ±10%, 1w.
R6	3501-R6	Resistor, fixed, film, 500,000 ohms, ±1%, ½w.
R7	3501-R7	Resistor, fixed, film, 150,000 ohms, ±1%, ½w.
R8A	3501-R8	Resistor, variable, WW, 7500 ohms, ±10%, 4w.
R8B		Resistor, fixed, comp, as req. to bring R8A into calibration.
R8C		Resistor, fixed, comp, as req. to bring R8A into calibration.
R9, 16	3501-R9	Resistor, fixed, comp, 10 meg., ±10%, ½w.
R10, 11	3501-R10	Resistor, fixed, comp, 18 meg., ±10%, ½w.
R12	3501-R12	Resistor, variable, WW, 1000 ohms, ±20%, 2w; slotted for screwdriver adjustment.
R13	3501-R13	Resistor, variable, WW, 285 ohms, ±10%, 2w.
R14	3501-R14	Resistor, fixed, WW, 500 ohms, ±5%, 10w.
R15, 18, 19	3501-R15	Resistor, fixed, comp, 470k, ±10%, ½w.
R17	3501-R17	Resistor, fixed, WW, 1000 ohms, ±5%, 5w.
R20	3501-R20	Resistor, fixed, WW, 270 ohms, ±10%, 1w.
R21	3501-R21	Resistor, fixed, comp, 300 ohms, ±5%, ½w.
R22	3501-R22	Resistor, variable, comp, .5 meg., ±20%, ½w.
R23	3501-R23	Resistor, fixed, comp, 560k, ±10%, 1w.
R24	3501-R24	Resistor, fixed, comp, 3 meg., ±5%, ½w.
R25	3501-R25	Resistor, fixed, film, 12,000 ohms, ±1%, 1w.
R26	3501-R26	Resistor, matched pair, 83,000 ohms, ±1%, 2w.
R27	3501-R27	Resistor, matched pair, 25,000 ohms, ±1%, 2w.
R28	3501-R28	Resistor, fixed comp, 47 ohms, ±10%, 1w.
S1	3501-S1	Switch, slide spdt., momentary.
S2	3501-S2	Switch, push-button, 7 position.
S3	3501-S3	Switch, slide dp4t.
S4	3501-S4	Switch, rotary 3pdt.
S5	3501-S5	Switch, slide dpdt.
S6	3501-S6	Switch, slide spdt.
T1	3501-T1	Transformer, primary, 115v secondaries:—2.5v; 12v tapped at 10v; 800 tapped at 400, 600 and 700; 140 volts C.T.

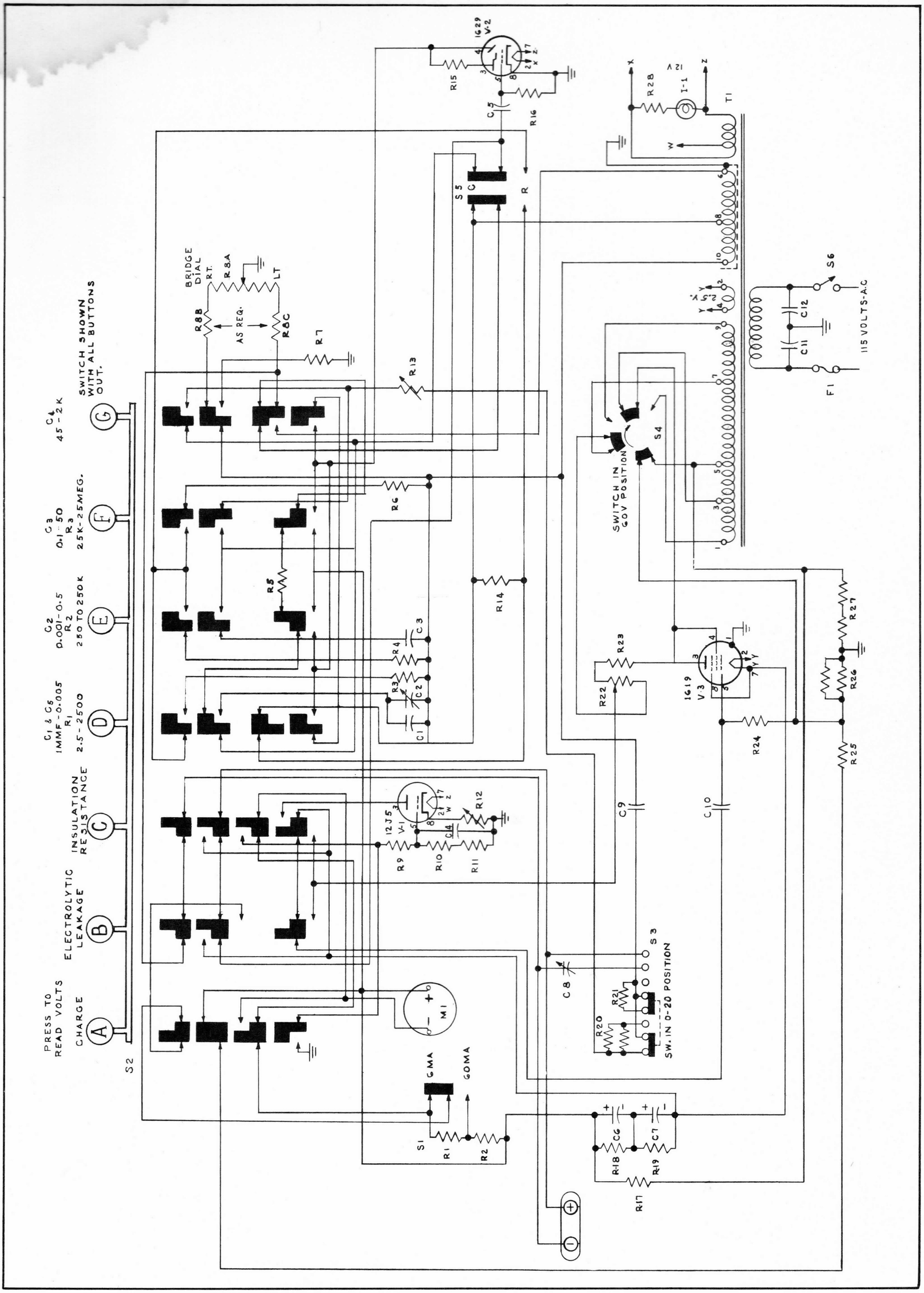

FIGURE 10. SCHEMATIC DIAGRAM VO-41